Fact Sheet
United States Nuclear Regulatory Commission
Office of Public Affairs
Washington DC 20555
Telephone: 301/415-8200   E-mail: opa@nrc.gov

Research and Test Reactors

Background

Research and test reactors -- also called "non-power" reactors-- are nuclear reactors primarily used to conduct research, development and education. These reactors contribute to almost every field of science including physics, chemistry, biology, medicine, geology, archeology, and environmental sciences.

The U.S. Nuclear Regulatory Commission (NRC) licenses research and test reactors (listed at the end) 36 of which are currently operating. The rest either are in the process of removing radioactive material from the facility (decommissioning), or have licenses to possess radioactive material but not to operate (possession only). Most of these research and test reactors are at universities or colleges in the United States. Since 1958, NRC and its predecessor, the Atomic Energy Commission, have decommissioned seventy-three research and test reactors. The Department of Energy (DOE) also has several of these reactors, which the NRC does not license.

Regulatory Oversight

Licensing

The NRC licenses research and test reactors consistent with NRC regulations to ensure an acceptable level of safety. These licenses include authorization for operation, and possession of radioactive material. Licensing actions include license renewals, extensions, authorizations for decommissioning, license terminations after completion of decommissioning, for conversions to low-enriched uranium fuel, and power upgrades. For certain technical issues and safety standards development, NRC coordinates with such organizations as the National Organization of Test, Research, and Training Reactors, the American Nuclear Society, and the International Atomic Energy Agency.

Inspection

The NRC uses a graded approach in its inspection program, i.e., less frequent and detailed inspections at facilities that pose a lower risk.

For inspection of operating research and test reactors, the NRC maintains two protocols.

> 1) For reactors licensed to operate at power levels of 2 megawatts (2,000,000 watts) or greater, the inspection program is completed annually.
>
> 2) For reactors licensed to operate at power levels below 2 megawatts, the inspection program is completed in two years.

The inspection program for operating reactors includes review of: operational activities, design control, review and audit functions, radiation and environmental protection, operator requalification, maintenance and surveillance activities, fuel handling, experiments, procedural controls, emergency preparedness, transportation, security, and material control and accounting. The inspection program also encompasses a review of organizational structure and qualifications and responsibilities of reactor personnel. If the inspection program identifies violations of requirements, the NRC takes appropriate enforcement action. The NRC inspection program also includes following up on allegations of safety or regulatory concern.

For reactors that are in a "possession only" status (i.e., in a safe storage condition), the NRC completes its inspection programs every three years. For reactors that are in the process of decommissioning, the NRC inspects selected aspects of the licensee's safety programs and activities.

Operator Licensing

The NRC issues six-year licenses to Reactor Operators and Senior Reactor Operators. Reactor Operators are licensed to operate the reactor under most conditions without supervision. However, during some plant conditions, a Senior Reactor Operator must be present. In addition, Senior Reactor Operators are responsible for plant conditions during emergencies.

To be licensed, Operators and Senior Operators must have the required knowledge, skills and abilities to control the reactor during both routine operations and emergencies. As part of the initial operator licensing process, NRC prepares and administers both a comprehensive written examination and a hands-on operating test. These examinations are based on the requirements of the Commission's regulations (in 10 CFR Part 55).

Reactor Operators and Senior Operators are required to maintain their expertise. Each facility is required to maintain a Requalification Program, covering both refresher training (material covered during initial licensing) and training on systems recently changed. The training program is divided into two-year cycles and requires a comprehensive written examination and annual operating tests. The reactor staff administers these examinations. NRC inspectors determine if the licensee meets the Requalification Program requirements. At the end of the six-year period, Operators and Senior Operators are required to submit an application to renew their license. As part of the application, reactor management must certify satisfactory participation in the Requalification Program.

Research and Development Activities

In research reactors, the radiation is the useful product not the very little amount of energy produced. Primarily, two types of radiation are used from research reactors: neutrons and gamma rays. Some experiments require more of one type radiation than the other. The amount and types of radiation may be controlled by placing different types of “filters” between the reactor and the experiment, or positioning the experiment at different positions relative to the radioactive fuel in the core.

Experimenters use different types of experimental facilities to expose the material to the required types of radiation. Experimental facilities include in-core radiation “baskets,” pneumatic (air-operated) tubes (similar to systems used at drive-through banks), and beam tubes (holes in the shielding around the reactor which can direct a beam of radiation to the experiment).

One of the more popular types of experiment is beam scattering. This process is similar to X-rays at the dentist's office or at a hospital. Radiation from the reactor is directed at the material to be studied. The manner in which the radiation interacts and bounces off, or scatters, from the material yields information on structure and properties. Radiation from research and test reactors (such as neutrons) can be used to study material characteristics that cannot be readily measured otherwise.

Neutron scattering is an important tool in experiments dealing with superconductors, polymers, metals, and proteins. Researchers can analyze molecular structure, surfaces and interfaces, measure electronic and magnetic properties, stress and strain conditions, and gauge other characteristics. These experiments are also used in the determination of structural integrity for aerospace, automotive and medical components, and for the enhancement of gemstones.

Neutron activation analysis is a very powerful tool in the detection of very small (trace) amounts of material. Research and test reactors are routinely used to measure the presence of trace elements such as environmental pollutants in soil, water, air, and foods with an accuracy of several parts per billion. Neutron activation may also be used to create new radioactive isotopes such as radio-pharmaceuticals (radioactive material used in medicine) and processing of silicon prior to use in computer chips.

Materials used in power reactors are irradiated at research and test reactors to assess the change in characteristics from exposure to radiation. These changes are important in assessing safety functions and in considering license extension at power reactors.

Another use of research and test reactors, which is being studied, is to use neutrons for the treatment of cancerous tumors.

Research and Test Reactor Design and Safety Features

NRC research and test reactors are typically licensed according to the total thermal (heat) energy produced by the reactor. These facilities range in size from 0.10 watt to 20 megawatts (thermal). In contrast, a typical commercial nuclear power reactor is rated at 3,000 megawatts (thermal). Because of this large difference in power generated, the consequence of an accident at a research and test reactor is limited when compared to a commercial power reactor. For this reason, adequate emergency planning zones to protect the public from potential radiological accidents are well within owner controlled areas, often only to the boundary of the room in which the reactor is housed.

All research and test reactors have radiation monitors to measure radiation fields, and the larger facilities have monitors which measure particulate and gaseous releases to the environment.

Research and test reactors have many varieties and forms. Reactors may be classified by the type of material used to slow down the neutrons which cause fission. Typical moderators include water (H_2O), heavy water (D_2O), polyethylene, and graphite.

Water moderated reactors (the predominant type of reactor licensed by NRC) can be further classified as either pool-type or tank-type. Pool-type reactors have a core immersed in an open pool of water. The pools typically have about 20 feet of water above the core to allow cooling and radiation shielding. At pool-type reactors, the operating core can be observed through the pool water. Tank-type reactors have a core that is in a tank with water, sealed at the top.

Reactors may also be classified by the type of fuel used, such as MTR (plate type fuel) or TRIGA fuel. TRIGA fuel is unique fuel in that a moderator (hydrogen) is chemically bonded to the fuel.

All NRC-licensed research and test reactors have a built-in safety feature, which reduces reactor power during potential accidents before an unacceptable power level or temperature could be reached.

Unlike power plants, research and test reactor control rooms are usually in the confinement or containment area. Facility staff and personnel work in the reactor room or building during operation. Most research and test reactors are in rooms or buildings that have a dedicated ventilation system. Some research and test reactors have confinements that maintain a negative pressure with respect to the surroundings. This ensures that any radiation released is controlled. Others have a containment that can control potential high-pressure conditions.

All research and test reactors have fail-safe shutdown systems. Before an unsafe condition occurs, control rods rapidly reduce the reactor power level. Redundant systems to initiate a reactor shutdown also help protect the public. Reactors less than two megawatts do not generate enough heat to be a problem in case of a loss-of-coolant accident. Research and test reactors larger than two megawatts have auxiliary features and systems capable of adding water. The source of water can be a water tank or a source of city water. Because of the low power levels at which research and test reactors operate they only require this cooling for short periods after shut down. In addition, many of these reactors operate on a very limited schedule, and so have a limited amount of radioactive material.

Post 9/11 Security Measures

The NRC sent out “advisories” to all research and test reactor licensees following the September 11, 2001, terrorist attacks. These advisories were written to sensitize licensees to potential threats and the need to consider certain security measures. These measures included restricting activities and personnel to those considered essential, reviewing security procedures, enhancing access control, and coordinating with local law enforcement and other federal agencies. All reactors have put measures
in place and remain in a heightened state of security awareness.

Research and Test Reactors Licensed To Operate

Aerotest Operations Inc., San Ramon, CA.
Armed Forces Radiobiological Research Institute, Bethesda, MD.
Cornell University, Ithaca, NY.
Dow Chemical Company, Midland, MI.
General Electric Company, Sunol, CA.
Idaho State University, Pocatello, ID.
Kansas State University, Manhattan, KS.
Massachusetts Institute of Technology, Cambridge, MA.
National Institute of Standards and Technology, Gaithersburg, MD.
North Carolina State University, Raleigh, NC.
Ohio State University, Columbus, OH.
Oregon State University, Corvallis, OR.
Penn State University, University Park, PA.
Purdue University, West Lafayette, IN.
Reed College, Portland, OR.
Rensselaer Polytechnic Institute, Schenectady, NY.
Rhode Island Atomic Energy Commission, Narrangansett, RI.
Texas A&M University, College Station, TX. (two reactors)
University of Arizona, Tucson, AZ.
University of California-Davis, Sacramento, CA.
University of California, Irvine, CA.
University of Florida, Gainesville, FL.
University of Maryland, College Park, MD.

University of Massachusetts, Lowell, MA.
University of Michigan, Ann Arbor, MI.
University of Missouri, Columbia, MO.
University of Missouri, Rolla, MO.
University of New Mexico, Albuquerque, NM.
University of Texas, Austin, TX.
University of Utah, Salt Lake City, UT.
University of Wisconsin, Madison, WI.
U.S. Geological Survey, Denver, CO.
U.S. Veterans Administration, Omaha, NE.
Washington State University, Pullman, WA.
Worcester Polytechnic Institute, Worcester, MA.

Research and Test Reactors Under Decommission Orders or License Amendments

These research and test reactors are authorized to decontaminate and dismantle their facility to prepare for final survey and license termination.

CBS Corporation, Waltz Mill, PA.
General Atomics, San Diego, CA. (two reactors)
Georgia Institute of Technology, Atlanta, GA.
Iowa State University, Ames, IA.
Manhattan College, Riverdale, NY.
National Aeronautics and Space Administration, Sandusky, OH. (two reactors)
Saxton Nuclear Experimental Corporation, Saxton, PA. (one power reactor)
University of Illinois, Urbana, IL.
University of Washington, Seattle, WA.
University of Virginia, Charlottesville, VA. (two reactors)

Research and Test Reactors With Possession-Only Licenses

These research and test reactors are not authorized to operate the reactor, only to possess the nuclear material on-hand. They are permanently shut down.

Cornell University Zero Power Reactor, Ithaca, NY.
General Electric Company, Sunol, CA. (two research and test reactors, one power reactor)
Nuclear Ship Savannah, James River Reserve Fleet, VA. (one power reactor)
State University of New York, Buffalo, NY.

January 2004